# WIND ENERGY SKILLS DEVELOPMENT THROUGH THE DSTI'S RENEWABLE ENERGY HUB AND SPOKES PROGRAMME



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# CONTENTS


1. 2019 White Paper on STI
2. DSTI Mandate
3. DSTI RDI Flagship Programmes
4. Renewable Energy Hub and Spokes Programme
5. Research and skills development relevant to wind energy

# 2019 STI Plan

## White Paper on Science Technology and Innovation calls for:

- Fully-fledged Department of Science Technology and Innovation (DSTI) with the mandate of a:
  - Responsive, coordinated and efficient ***National System of Innovation***
  - Human capital development for science
  - Increased knowledge generation
  - Using knowledge for economic ***and inclusive*** development
  - Innovation for a capable state
- The 2019 White Paper highlights the need for:
  - Triple Helix Model (Higher Education Institutions, Public Sector, Private Sector and society) in innovation initiatives
  - International partnerships
  - Support for locally developed of IP or know how
  - Support for SMMEs

# DSTI MANDATE

- The Department of Science Technology and Innovation's (DSTI) mandate is derived from the 2019 Science, Technology and Innovation (STI) White Paper.

- The DSTI Energy Research, Development and Innovation (RDI) Programmes support:

- Reduction in greenhouse gas emissions and air pollution.
- Diverse and sustainable energy mix.
- Research, development and validation efforts to enable emerging technologies to be competitive in terms of cost and performance.
- Local beneficiation & sustainable value chains through leveraging domestic resource endowment.
- Knowledge generation and skills development.
- Strategic partnerships: international partners, PPP & community engagement.

# DSTI MANDATE

- **The Decadal Plan is the implementation plan for the 2019 White Paper on Science, Technology and Innovation (STI)**

- **The Decadal Plan theme is:**

***"deepening knowledge economy for enhanced socio-economic impact"***

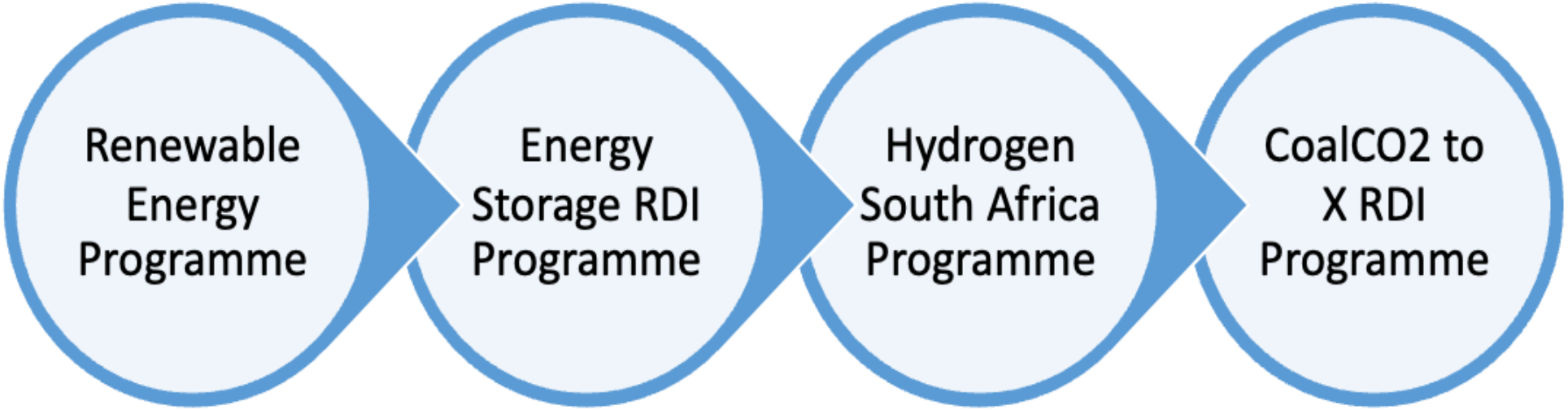
- ***STI Priorities***

Energy Innovation

Circular Economy

Health Innovation

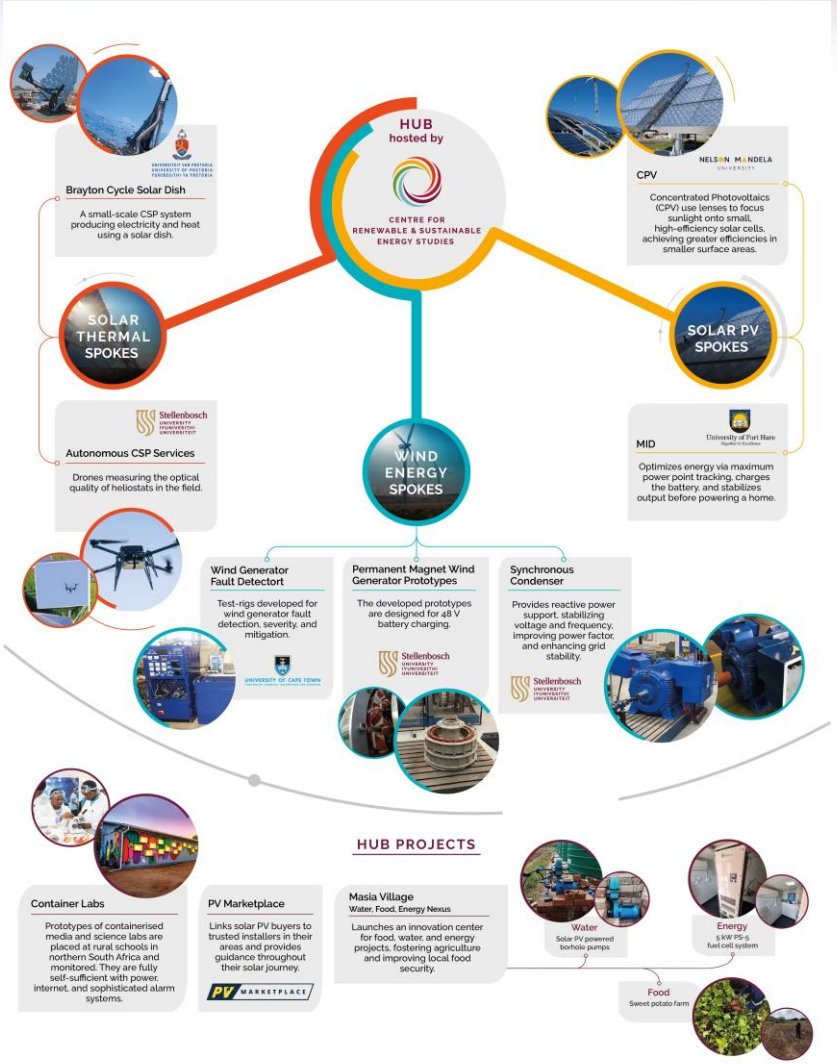
# DSTI RDI FLAGSHIP PROGRAMMES



# RENEWABLE ENERGY HUB AND SPOKES PROGRAMME

- The focus is on Advances in Renewable Energy (RE) technology innovation along with skills development at a postgraduate level to increase the knowledge base.

- The programme conducts research on wind energy technologies (turbines from 3 kW to 300 kW), Solar Photovoltaics, materials, modules, building integrated Photovoltaics systems, Hybrid concentrator PV systems, Concentrated Solar Power.



# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

**Focus Areas:**

- Drive-train technology
- Solid-state converters & control
- Grid integration and forecasting
- Condition monitoring and diagnostics

**Relevance to DSTI priorities:**

- Improving resilient of energy infrastructure:
  - Condition monitoring, diagnostic techniques of RE technology
  - Development of lab-based facility for assessment of RE integration issues
- Climate crisis and impact of new technologies; Drive inclusive growth and job creation:
  - Advanced manufacturing techniques,
  - Localisation, circularity of RE technology
- Reduce poverty and tackle high cost of living:
  - Increased efficiency and reliability of energy infrastructure improves energy availability and defers need for new energy infrastructure

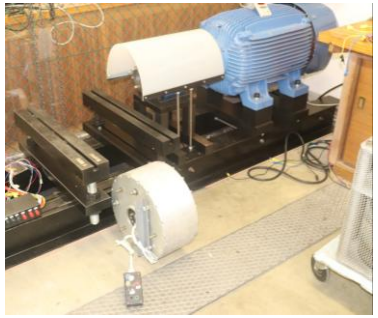
# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

**Drive-train technology – Wind Generator Design:**

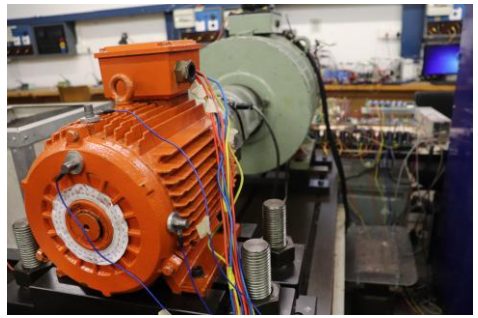
- Various traditional radial, axial-flux Permanent Magnet (PM) generator topologies prototyped, tested – TRL 3
- Permanent Magnet Vernier generator with improved torque capability, minimized leakage harmonic flux prototyped, tested – TRL 3
- Flux-switching Permanent Magnet Vernier generator prototyped, tested – TRL 3
- Scaled Doubly-fed Induction Generator (DFIG) for condition monitoring prototyped, tested - TRL N/A











# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

**Solid-state converters & control – Converters for Renewable systems:**

- Grid-forming / Grid-following inverter for Doubly-fed Induction Generators (DFIG):
  - Grid connected versus Islanded mode of operation and transition between operating modes

- Electric drives for modern wind generators:
  - Electric drives for flux-switching Permanent Magnet machines,
  - Electric drives for Permanent Magnet Vernier machines.

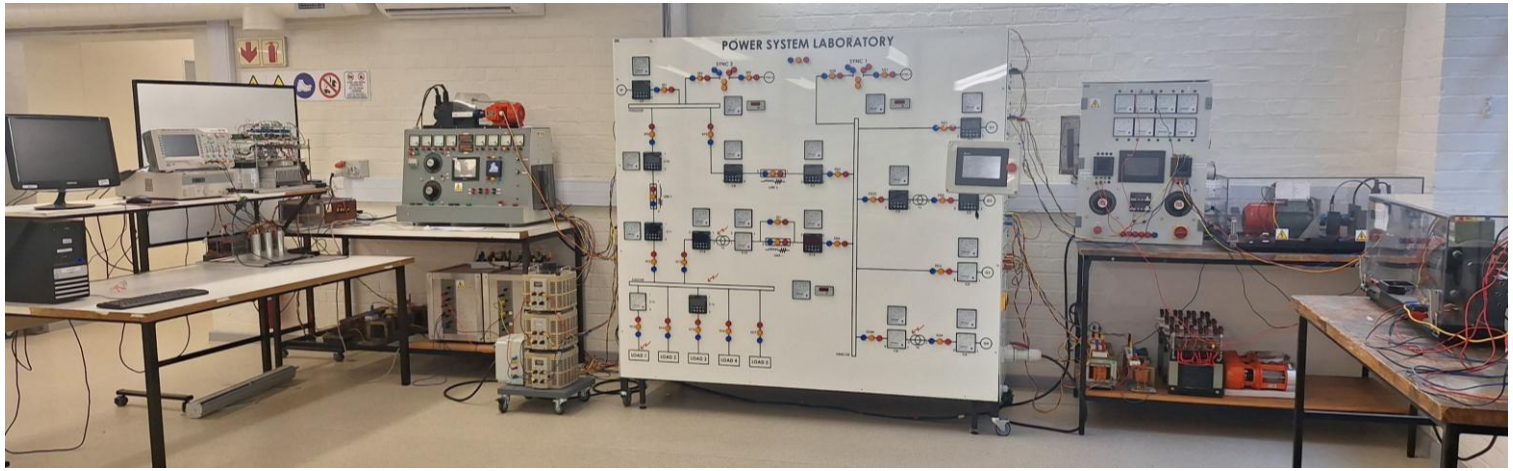
- Converters for Renewable applications:
  - Multi-level converter topologies for RE applications
  - Multi-port Converters
  - Grid forming, grid following converter performance
  - High-gain boost converters
  - Boost inverter topologies
  - Buck inverter topologies

# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

**Grid integration and forecasting:**

- UCT Microgrid – Platform developed for Renewable Energy integration studies
- Lab-scale prototype for Power Hardware-in-the-Loop (PHiL) real-time emulation, testing Renewable Energy integration issues
- Inverter-based sources, loads, generators, and Opal-RT PHiL system incorporated
- Battery Energy Storage System (BESS) emulator incorporated
- TRL 3 – lab-based system for partnerships with Eskom, IPPs, Municipalities, local Gov, etc.



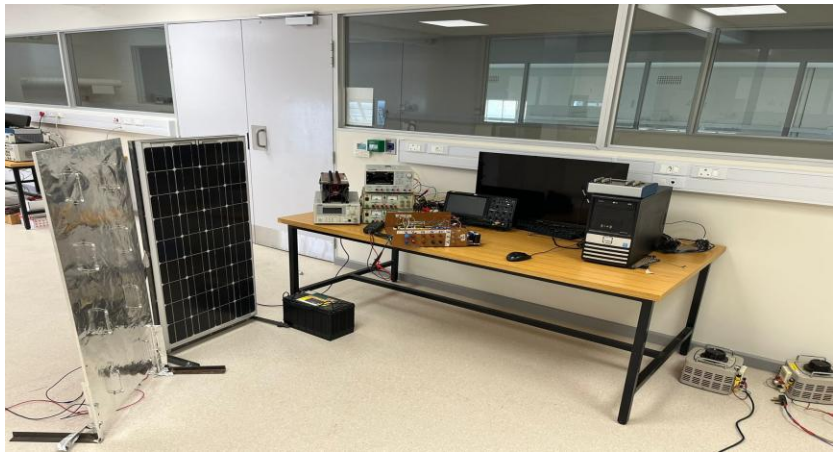


# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

**Condition monitoring – Condition monitoring, diagnostics of Renewable Energy technology:**

- Test-rigs developed for fault detection, severity analysis and mitigation in wind generators: Doubly-fed Induction Generators (DFIGs) and Permanent Magnet Synchronous Generators (PMSGs)
- Advanced signal processing techniques used for diagnosis.
- Condition monitoring work extended to PV modules, fuel cells, battery energy storage systems.
- Real-time characterisation & fault classification of PV modules, fuel cells using impedance spectroscopy.





# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

**Synchronous condenser for:**

- **Reactive Power Control:** They continuously generate or absorb reactive power (VARs) by adjusting their DC rotor field excitation. When overexcited, they supply leading reactive power to support dropping voltages; when under-excited, they absorb lagging reactive power.
- **Voltage Regulation:** By dynamically managing reactive power, they stabilize voltage levels at weak transmission nodes, heavy industrial sites, and renewable energy integration points.
- **Synchronous Inertia:** Because their heavy rotors spin in sync with the grid frequency, they provide rotational kinetic energy. This mechanical inertia slows down the rate of frequency change during sudden load shifts or generation losses.
- **Short-Circuit Strength and Fault Support:** They supply inherent short-circuit fault current (up to several times their nominal rating), which helps protective relays and circuit breakers trip correctly during grid disturbances.
- **Power Factor Correction:** They offset the lagging power factor caused by inductive loads (such as large motors and transformers), improving the overall efficiency of the electrical network



# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

- 4.2 kW wind turbine generator on test bench and turbine blade.

- **Specifications**

- Direct drive PM
- 3-Phase
- 4.2 kW
- 100 – 320 r/min



# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

- Eskom utilizing micro-grids for off-grid solutions, they conducted feasibility studies in 40 sites, and they have started with installation of some micro-grids.
- 4 kW wind turbine developed under the renewable enrgy programme successfully integrated into the Eskom micro-grid.
- Testing of the 4 kW turbine currently underway, the turbine can be scaled up to 300 kW



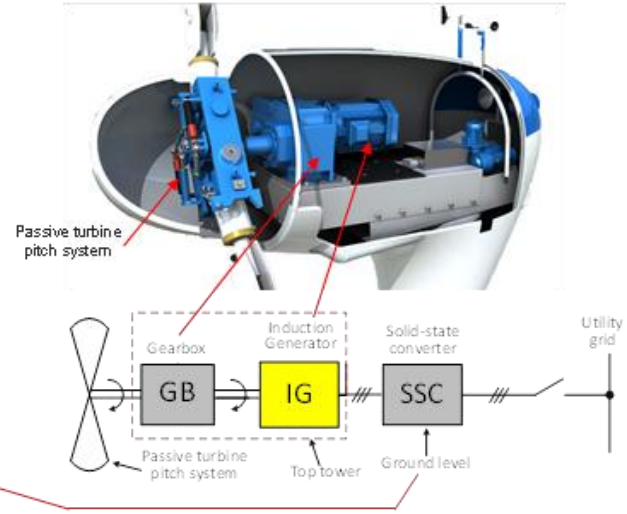
# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

- The system consists of a two-bladed turbine with passive blade-pitch variation; this means that the blades automatically pitch at certain turbine speeds to keep the power constant at high wind speeds.

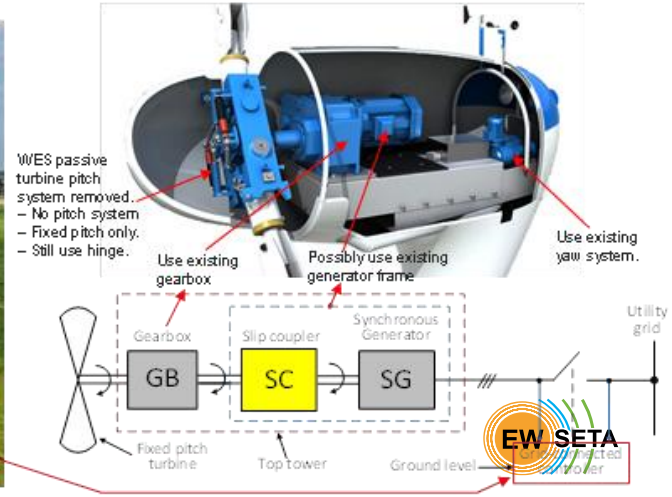
- The turbine is coupled to a standard Flender gearbox and ABB induction generator. The induction generator in turn is connected to the three-phase power grid via a ABB back-to-back IGBT solid-state converter. The turbine system has a controlled yaw system for safety and switching-off the turbine. TRL 9, Background IP owned by WES.

- The new slip-synchronous drive-train technology will be incorporated into the existing 250 kW WES wind turbine system. Any foreground IP will be protected in line with IP stipulations in the signed collaboration agreement.







# RESEARCH AND SKILLS DEVELOPMENT RELEVANT TO WIND ENERGY

❖ **The training in the various research areas include the following:**

- **Doctoral students (Electrical Engineering)**
- **Masters Students (Electrical Engineering)**
- **Technicians**
- **Technologists**
- **Artisans**

# THANK YOU

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